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Quantitative Study of Phytodiversity at Churu, Rajasthan, India

Dr. Prashant Kumar Sharma
Lecturer in Botany, Government Lohia College, Churu, Rajasthan, India

ABSTRACT

Biodiversity of plants collectively known as "plant genetic resources" is a key component of any agricultural production system, indeed, of any ecosystem, without which natural evolutionary adjustment of the system to the changing environmental and biotic conditions would be impossible. Plant biodiversity is an irreplaceable resource, providing raw materials for introductions, domestication as well as improvement programme in agriculture and forestry. A decline in biodiversity entails the loss of species of genes from an ecosystem with unpredictable effects for the long-term survival of that system. This disappearance of species has been described as a loss of plants and animals with potential agricultural and economic value as a threat to the global climate and the environment for human existence. A population consists of organisms of a particular species, but when several populations share a common habitat and its resources, they interact among themselves and develop into a biotic community. A population consists of an organism of a particular species, but when several populations share a common habitat and its resources, they interact among themselves and develop into a biotic community. The composition of a community in any habitat is depending upon the environmental conditions and ecological amplitude of species populations. In a community, plants of one or more species are more prominent than the others because they are present in considerable numbers and largely control the environment. These are called dominants and they determine what other species may grow in the community. The members of a community compete with each other for factors of the environment such as light, water and mineral nutrients. Community structure, composition, shape and so on are called qualitative features while the measurement of density, frequency of occurrence, height, coverage, and growth represent the quantitative features.

Keywords: *Biodiversity, Population, Community, Qualitative and quantitative features*

A. INTRODUCTION

In a community soil conditions, seed dispersal mechanisms, grazing pattern, biotic interference, etc. are varied, so this directly affects the dispersion of a species population in community. Frequency values differ in different communities due to varied environmental conditions. By his finding Raunkaier (1934) established the law of frequency which has been accepted that this law occurs in communities where disturbance is minimum. The numerical strength of organisms in a community represents their number per unit area. In frequency and density studies, the size of the quadrat is very important.

The **alpha diversity** of any location is a balance between the actions of local biotic and abiotic elements of the environment, and immigration from other locations (Whittaker, 1960). Both the component of alpha diversity, i.e. species richness and evenness could be assessed separately or by through a unified index. Most of the index is sensitive to the size of the sample. These indices are formulated in number of individuals or in biomass or in cover. The size of individuals in different species also affects the indices.

Species diversity is considered a rough proxy for biodiversity. A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance. As species richness and evenness increase, so diversity increases. **Simpson's Diversity Index** is a measure of diversity which takes into accounts both richness and evenness. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present as well as the abundance of each species. Biological diversity can be quantified in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. The more species present in a sample, the 'richer' the sample. Species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. Evenness is a measure of the relative abundance of the different species making up the richness of an area.

Species diversity is quantified by calculating "Species Diversity Index" which is the ratio between the number of species and importance value or number or biomass or productivity of the individual. Shannon and Weaver used a formula for calculating "Shannon-Wiener Index" of general diversity. It is based on the information theory and the information content is a measure of the amount of uncertainty. The index is zero if there is only one species in the sample and maximum when all species are represented by the same number of individuals. It generally falls between 1.5 and 3.5, and rarely exceeds 4.5 (Margalef, 1972). Pielou (1966) suggested that this index is valid on random samples which were taken out from a large community with known species number. This index is affected more by the addition of rare species with increasing sample size than Simpson's Index (Peet, 1974; Clementine et al., 1998).

In the present studies, an attempt has been made to study the quantitative characters of phytobiodiversity at Churu, a district headquarters at Rajasthan, India during the summer, rainy and winter season at three different sites in year 2014-2016.

B. Materials and Methods-

A detailed mapping and floristic ecological survey of three study sites during three seasons of the year to know the prevailing biological diversity at Churu. Excursions were undertaken once in a month but in rainy months' frequency of visits extend up to once a week. Identification and listing of native plant species is by standard floras. For quantitative characters, the predetermined quadrat of 100 cm^2 is placed for 10 times at the study site randomly. Individuals counts were made species-wise for all species that occurred within a quadrat. The various parameters as given below were analyzed as per standard methods. Frequency, density and abundance were calculated by using their respective formulae (Curtis, 1959).

Frequency is the unit of occurrence of particular species in the sampling process and is expressed in percentage. Density is the number of individuals per unit area and Abundance is the number of individuals per unit area of their occurrence. Using the basic quantitative parameters, the relative importance of each species in the community was also computed in terms of relative frequency, relative density, relative abundance and relative dominance. Basal area is main character to determine dominance (Mishra, 1968). For measurement of Importance Value Index (IVI) all relative values were summed up.

Simpson Index (Simpson, 1949) is the measurement of concentration of dominance that ranges from 0 to 1. Where 1 indicates the vegetation of single species and lower values indicating the sharing of dominance. It is denoted by "C" and the function for infinite sample is:

$$\mathbf{C=\sum P_i^2}$$

Where, P_i is the importance value of the species obtained using n_i / N, n_i is the number of individuals of i^{th} species in the sample and N is the total number of individuals of all species in the sample.

For representing diversity (D), Simpson Index is subtracted from the maximum possible value of 1 (Greenberg, 1956; Berger and Parker, 1970), i.e.

$$\mathbf{D = 1- C}$$

Shannon-Wiener Index (Shannon and Weaver, 1949) is the measurement of species diversity in vegetation. And it is denoted by **H** and the function is:

$$\mathbf{H= -\sum [Pi \log_e Pi]}$$

The measurement of evenness is Pielou Index, denoted by e and obtained by using following function:

$$\mathbf{e = H / \log_{10} S}$$

(Here, S is the number of species)

Cody's measure for beta diversity is expressed as:

$$\mathbf{B = 1- C \frac{(S_1 + S_2)}{S_1 S_2}}$$

(Where, S_1 and S_2 are the number of species in sampling sites 1 and 2, respectively; and C is the number of species that are shared by sites 1 and 2)

All the species are sequenced in the descending order of Important Value Index (IVI). Now in x-x^i axis species sequenced and in y-y^i axis the IVI are assigned. The line connecting the co-ordinate points is the Dominance-Diversity Curve. Based on DD curve, the vegetation is identified as undisturbed (Sigmoidal), in harsh condition (Geometric) or with intense interspecific competition and territorial behavior (Broken stick) with niche overlapping, niche non-overlapping, random niche boundaries, respectively (Whittaker, 1965, 1972).

To measure the distribution pattern of vegetation at the study site abundance and frequency (A/F) ratio was calculated as per Whitford (1949) and based on this community can be classified either regular, random or contagious.

Regular = A/F < 0.025; Random = 0.025 to 0.05;

Contagious = A/F > 0.05

C. Observations

The data on quantitative studies, viz. frequency, density, abundance, dominance and importance value index (IVI) are presented in Tables 1 to 5. It is evident from these tables that frequency ranged from10 to 90% in rainy, while 10 to 80% in winter and summer seasons at all sites. In rainy season, plant species such as *Aristidia funiculata, Cenchrus biflorus, Cynodon dactylon, Mollugo cerviana, Tephrosia purpurea* and *Tribulus terrestris* show maximum frequency at site-I and *Cenchrus biflorus, Cyperus rotundus, Gisekia pharnacioides* and *Mollugo cerviana* at site-II. Plant species which exhibited maximum frequencies at site-III were: *Cenchrus biflorus* and *Mollugo cerviana.* In winter, *Chenopodium murale* & *Tephrosia purpurea* at site-I, *Crotalaria burhia* at site-II and *Calotropis procera* & *Tephrosia purpurea* at site-III showed maximum frequencies. In summer, *Tephrosia purpurea* (sites-I & II) and *Crotalaria burhia* (site-III) showed maximum frequencies.

Density ranged from 0.1 to 7.4, 0.1 to 8.7 and 0.1 to 6.5 in rainy season at sites-I, II and III, respectively. *Mollugo cerviana, M. nudicaulis* and *Gisekia pharnacioides* shows highest densities in rainy season at sites-I, II and III, respectively. It ranged between 0.1 to 2.4, 0.1 to 1.8 and 0.1 to 2.6 in winter and between 0.1 to 1.9, 0.1 to 2.4 and 0.1 to 2.0 in summer at sites-I, II and III, respectively.*Cenchrus biflorus* (site-III) and *Tephrosia purpurea* (site-II) showed maximum density in winter and summer seasons, respectively.

Abundance ranged from 1.0 to 9.0, 1.0 to 14.5 and 1.0 to 9.2 in rainy, from 1.0 to 4.0, 1.0 to 3.6 and 1.0 to 4.7 in winter and from 1.0 to 4.0, 1.0 to 3.3 and 1.0 to 2.6 in summer seasons at sites-I, II and III, respectively. *Mollugo nudicaulis, Cenchrus ciliaris* and *Aerva pseudotomentosa* showed maximum abundance during rainy, winter and summer seasons, respectively.

At all the sites, the highest values of dominance were recorded for *Corchorus depressus* (36.1) in rainy, *Prosopis cineraria* (15.1) in winter and during summer for *Tecomella undulata* (17.4). Regarding IVI (Table 3.5), it ranged between 0.43 to 13.89, 0.49 to 11.9 and 0.57 to 12.40 in rainy, 1.32 to 17.6, 1.31 to 11.9 and 1.11 to 19.10 in winter and 1.69 to 31.20, 1.50 to 22.70 and 2.02 to 25.90 in summer seasons at sites-I, II and III, respectively. Plant species such as *Corchorus depressus, Calotropis procera* and *Tecomella undulata* showed maximum IVI during rainy, winter and summer at all sites, respectively.

The values of different parameters such as diversity indices, species richness, A/F ratio, beta diversity, etc. of studied sites are presented in Tables 5 to 7. The Simpson Index was maximum in summer at all the sites. The Shannan-Wiener Index ranged from 3.034 to 3.891 in all seasons at studied sites. Although, the number of plant species at sites-I & II were lesser in winter than rainy season, the species richness was highest in winter at these sites. It was maximum in rainy at site-III. For studying of vegetation distribution patterns, abundance and frequency (A/F) ratio was calculated and it ranged from 0.059 to 0.088, 0.056 to 0.092 and 0.042 to 0.071 at Sites-I, II and III, respectively. These data showed that distribution patterns were contagious type at all sites except in summer at site-III, which showed random.

The values of beta diversity between studied sites recorded were: - 0.657, -0.585 and -0.658 in rainy, winter and summer, respectively. The overall landscape diversity of the studied area was recorded 6.914 in rainy, 7.194 in winter and 6.817 in summer season.

The dominance-diversity curves of studied sites reveal that all the curves obtained during studied period in seasons were sigmoidal, however it was less sigmoidal in summer.

Table 1 Basic quantitative parameters of plant species in various seasons at site-I during 2014-2016

S. No.	Plant species	Rainy				Winter				Summer		
		F	D	A	Dom	F	D	A	Dom	F	D	A
1	Abutilon indicum	10	0.1	1.0	0.9	30	0.6	2.0	1.0	-	-	-
2	Acacia nilotica	10	0.1	1.0	10.0	20	0.3	1.5	1.1	20	0.2	1.0
3	A. senegal	10	0.1	1.0	3.7	10	0.1	1.0	0.7	10	0.1	1.0
4	Aerva pseudotomentosa	30	0.6	2.0	4.0	40	1.0	2.5	3.3	20	0.8	4.0
5	A. persica	20	0.2	1.0	0.7	50	1.3	2.6	0.4	60	1.6	2.7
6	Ageratum conyzoides	30	0.8	2.7	2.7	20	0.2	1.0	0.1	-	-	-
7	Albizia lebbek	10	0.1	1.0	3.7	10	0.1	1.0	1.3	10	0.1	1.0
8	Amaranthus blitum	50	3.3	6.6	0.8	30	0.6	2.0	0.3	-	-	-
9	Anagallis arvensis	-	-	-	-	60	4.5	7.5	7.7	-	-	-
10	Anticharis linearis	60	3.8	6.3	4.4	-	-	-	-	-	-	-
11	Argemone mexicana	10	0.2	2.0	4.3	30	0.4	1.3	0.9	40	1.0	2.5
12	Aristida funiculata	70	5.2	7.4	18.5	-	-	-	-	-	-	-
13	Arnebia hispidissima	40	2.6	6.5	13.7	-	-	-	-	-	-	-
14	Balanites aegyptiaca	10	0.1	1.0	5.1	10	0.1	1.0	0.5	20	0.2	1.0
15	Barleria cristata	20	0.2	1.0	1.9	20	0.6	3.0	0.8			
16	Blepharis sindica	60	4.6	7.7	20.9	30	1.1	3.7	0.5			
17	Boerhavia diffusa	40	0.7	1.8	9.6	20	0.5	2.5	6.1	-	-	-
18	Borreria articularis	60	2.8	4.7	4.7	-	-	-	-	-	-	-
19	Brachiaria ramosa	60	1.9	3.2	22.9	-	-	-	-	-	-	-
20	Calotropis procera	20	0.5	2.5	13.3	60	0.9	1.5	2.4	50	1.1	2.2
21	Capparis decidua	10	0.1	1.0	4.8	40	0.7	1.8	1.5	40	0.9	2.3
22	Citrullus lanatuss	30	0.5	1.7	0.3	-	-	-	-	-	-	-
23	Cenchrus biflorus	80	5.6	7.0	7.8	50	1.6	3.2	3.8	-	-	-
24	C. ciliaris	70	4.9	7.0	10.4	40	1.1	2.8	2.9	40	0.8	2.0
25	Chenopodium album	-	-	-	-	60	1.3	2.2	0.2	-	-	-
26	C. murale	-	-	-	-	70	1.9	2.7	0.3	-	-	-
27	Citrullus colocynthis	60	1.2	2.0	0.8	30	0.5	1.7	0.1	-	-	-
28	Cleome viscosa	40	0.9	2.3	0.6	20	0.3	1.5	0.4	-	-	-
29	Clerodendrum phlomidis	40	0.4	1.0	4.9	20	0.2	1.0	3.3	10	0.1	1.0
30	Corchorus depressus	70	5.2	7.4	36.1	50	1.2	2.4	0.8			
31	C. tridens	40	3.3	8.3	8.1	30	0.8	2.7	0.2			
32	Crotalaria burhia	30	0.9	3.0	3.1	70	2.1	3.0	0.7	80	1.7	2.1
33	Ctenolepis cerasiformis	30	2.2	7.3	2.5	-	-	-	-	-	-	-
34	Cucumis callosus	20	0.3	1.5	0.4	-	-	-	-	-	-	-
35	Cyamopsis tetragonoloba	20	0.5	2.5	0.8	-	-	-	-	-	-	-
36	Cymbopogon jwarncusa	30	0.4	1.3	0.8	10	0.1	1.0	0.2	10	0.1	1.0
37	Cynodon dactylon	70	6.3	9.0	11.4	60	2.4	4.0	6.6	20	0.6	3.0
38	Cyperus arenarius	60	1.2	2.0	2.8	30	0.9	2.1	0.1	40	0.9	2.3
39	Dactyloctenium aegyptium	40	2.3	5.8	3.8	-	-	-	-	-	-	-
40	Datura inoxia	10	0.1	1.0	0.6	40	0.9	2.3	0.9	50	1.3	2.6
41	Desmostachya bipinnata	40	2.4	6.0	8.2	-	-	-	-	-	-	-
42	Dicoma tomentosa	30	0.7	2.3	2.1	20	0.5	2.5	1.9	-	-	-
43	Digeria muricata	40	0.5	1.3	3.0	-	-	-	-	-	-	-
44	Digitaria cilliaris	30	1.2	4.0	1.7	-	-	-	-	-	-	-
45	Echinops echinatus	30	1.1	3.7	0.1	-	-	-	-	-	-	-

46	Eclipta alba	20	0.6	3.0	2.1	-	-	-	-	-	-	-
47	Eragrostis ciliaris	60	1.4	2.3	2.5	-	-	-	-	-	-	-
48	Erianthus munja	30	0.3	1.0	2.7	20	0.3	1.5	3.2	10	0.1	1.0
49	Euphorbia hirta	40	0.6	1.5	2.0	-	-	-	-	-	-	-
50	E. granulata	30	0.6	2.0	2.2	-	-	-	-	-	-	-
51	Fagonia cretica	60	2.2	3.7	14.6	-	-	-	-	-	-	-
52	Farsetia hamiltonii	60	2.0	3.3	2.0	-	-	-	-	-	-	-
53	Gisekia pharnacioides	70	3.3	4.7	0.8	-	-	-	-	-	-	-
54	Glossocardia setosa	20	0.8	4.0	0.4	-	-	-	-	-	-	-
55	Heliotropium marifolium	10	0.1	1.0	0.2	-	-	-	-	-	-	-
56	H. ovalifolium	50	0.7	1.4	1.2	-	-	-	-	-	-	-
57	H. subulatum	40	1.5	3.8	0.3	-	-	-	-	-	-	-
58	Indigofera cordifolia	70	5.2	7.4	5.9	-	-	-	-	-	-	-
59	Launea procumbens	40	3.1	7.8	1.2	-	-	-	-	-	-	-
60	Leptadenia pyrotechnica	20	0.2	1.0	5.8	60	1.0	1.7	2.9	40	1.0	2.5
61	Lycium barbarum	30	0.6	2.0	7.0	20	0.4	2.0	0.5	40	0.9	2.3
62	Malva parviflora	20	0.2	1.0	0.6	-	-	-	-	-	-	-
63	Maytenus emarginata	10	0.1	1.0	3.7	10	0.1	1.0	0.4	20	0.3	1.5
64	Mollugo cerviana	90	7.4	8.2	3.4	-	-	-	-	-	-	-
65	M. nudicaulis	90	6.4	7.1	1.7	-	-	-	-	-	-	-
66	Momordica dioica	10	0.2	2.0	0.3	-	-	-	-	-	-	-
67	Parkinsonia aculeata	20	0.2	1.0	1.6	10	0.1	1.0	0.4	10	0.1	1.0
68	Pavonia arabica	10	0.1	1.0	1.4	-	-	-	-	-	-	-
69	Pedalium murex	10	0.1	1.0	0.3	-	-	-	-	-	-	-
70	Peristrophe bicalyculata	40	1.1	2.8	0.6	-	-	-	-	-	-	-
71	Vigna mungo	10	0.1	1.0	0.6	-	-	-	-	-	-	-
72	Phyllanthus amarus	30	0.5	1.7	0.8	-	-	-	-	-	-	-
73	Polygala irregularis	20	0.2	1.0	0.8	-	-	-	-	-	-	-
74	Prosopis cineraria	10	0.1	1.0	7.1	20	0.3	1.5	15.1	10	0.1	1.0
75	P. juliflora	10	0.1	1.0	8.3	10	0.1	1.0	9.6	20	0.2	1.0
76	Pulicaria crispa	30	0.7	2.3	0.7	-	-	-	-	-	-	-
77	Ricinus communis	10	0.1	1.0	0.7	10	0.1	1.0	1.3	10	0.1	1.0
78	Solanum surattense	30	0.5	1.6	1.1	10	0.3	3.0	0.8	20	0.6	3.0
79	S. nigrum	10	0.1	1.0	1.9	30	0.9	3.0	1.1	30	0.4	1.3
80	Sonchus asper	20	0.3	1.5	5.0	30	0.6	2.0	0.4	40	0.8	2.0
81	Tamarindus indica	10	0.1	1.0	1.3	10	0.1	1.0	0.8	10	0.1	1.0
82	Tecomella undulata	10	0.1	1.0	21.9	10	0.1	1.0	13.4	10	0.1	1.0
83	Tephrosia purpurea	80	4.0	5.0	6.8	80	2.1	2.6	1.2	70	1.9	2.7
84	Tetrapogon tenellus	30	1.4	4.7	1.3	-	-	-	-	-	-	-
85	Tragus biflorus	50	2.1	4.2	1.3	-	-	-	-	-	-	-
86	Trianthema portulacastrum	60	1.5	2.5	8.6	-	-	-	-	-	-	-
87	Tribulus terrestris	80	5.2	6.5	8.6	-	-	-	-	-	-	-
88	Trigonella corniculata	40	1.4	3.5	0.5	-	-	-	-	-	-	-
89	Verbesina encelioides	20	0.3	1.5	0.4	10	0.1	1.0	0.3	-	-	-
90	Withania somnifera	20	0.2	1.0	4.9	40	0.9	2.3	2.2	50	1.1	2.2
91	Xanthium strumarium	30	0.3	1.0	2.7	30	0.4	1.3	2.4	20	0.2	1.0
92	Zaleya redimita	50	0.7	1.4	0.3	-	-	-	-	-	-	-

F = Frequency, D = Density, Ab = Abundance, Dom = Dominanace, and - = Plants not seen.

Table 2 Basic quantitative parameters of plant species in various seasons at site-II during 2014-2016

S. No.	Plant species	Rainy				Winter				Summer		
		F	D	A	Dom	F	D	A	Dom	F	D	A
1	Acacia jacqemontii	10	0.1	1.0	0.7	20	0.2	1.0	1.7	20	0.2	1.0
2	A. nilotica	10	0.1	1.0	1.6	20	0.2	1.0	3.1	10	0.1	1.0
3	Aerva pseudotomentosa	40	0.8	2.0	0.5	40	0.9	2.3	0.6	30	1.0	3.3
4	A. persica	40	0.6	1.5	0.2	60	1.1	1.8	0.4	50	1.1	2.0
5	Ageratum conyzoides	30	0.6	2.0	0.3	20	0.3	1.5	0.1	-	-	-
6	Albizia lebbek	10	0.1	1.0	0.4	10	0.1	1.0	0.4	10	0.1	1.0
7	Amaranthus blitum	40	1.2	3.0	0.1	-	-	-	-	-	-	-
8	Anagallis arvensis	-	-	-	-	60	1.7	2.8	2.2	-	-	-
9	Andropogon pumilus	40	0.9	2.3	0.4	-	-	-	-	-	-	-
10	Anticharis linearis	50	1.9	3.8	2.2	-	-	-	-	-	-	-
11	Argemone mexicana	10	0.1	1.0	0.2	20	0.3	1.5	0.7	30	0.8	2.7
12	Aristida funiculata	50	1.0	2.0	1.2	-	-	-	-	-	-	-
13	Arnebia hispidissima	20	0.5	2.5	0.3	-	-	-	-	-	-	-
14	Balanites aegyptiaca	10	0.1	1.0	1.0	20	0.2	1.0	1.0	10	0.2	2.0
15	Blepharis sindica	60	1.8	3.0	0.8	30	0.7	2.3	0.3			
16	Boerhavia diffusa	30	0.5	1.7	1.0	40	0.7	1.8	1.3	-	-	-
17	Borreria articularis	40	1.4	3.5	0.4	-	-	-	-	-	-	-
18	Brachiaria ramosa	20	0.4	2.0	0.5	-	-	-	-	-	-	-
19	Calotropis procera	30	0.5	1.7	1.4	40	0.6	1.5	1.6	60	1.3	2.2
20	Capparis decidua	40	0.8	2.0	1.3	50	0.8	1.6	2.0	60	0.8	1.3
21	Cenchrus biflorus	80	3.2	4.0	0.4	60	1.4	2.3	0.2	-	-	-
22	C. ciliaris	70	2.1	3.0	0.5	50	1.1	2.2	0.2	-	-	-
23	C. setigerus	60	1.8	3.0	0.5	40	0.9	2.3	0.3	-	-	-
24	Chenopodium album	-	-	-	-	60	1.5	2.5	0.1	-	-	-
25	C. murale	-	-	-	-	60	1.8	3.0	0.2	-	-	-
26	Citrullus colocynthis	40	0.9	2.3	0.3	40	0.7	1.8	0.1	-	-	-
27	C. lanatus	30	0.5	1.7	0.1					-	-	-
28	Cleome viscosa	30	0.7	2.3	0.5	20	0.2	1.0	0.1			
29	Clerodendrum phlomidis	20	0.2	1.0	0.4	20	0.2	1.0	0.3	10	0.1	1.0
30	Convolvulus microphyllus	10	0.1	1.0	0.1	-	-	-	-	-	-	-
31	Corchorus depressus	60	2.2	3.7	8.8	60	0.9	1.5	0.2	-	-	-
32	C. tridens	40	2.9	7.3	2.7	50	0.8	1.6	0.6	-	-	-
33	Cordia gharaf	10	0.1	1.0	0.2	10	0.1	1.0	0.2	10	0.1	1.0
34	Crotalaria burhia	20	1.2	6.0	0.8	80	1.4	1.8	0.5	80	2.3	2.9
35	Ctenolepis cerasiformis	60	3.1	5.2	0.6	40	0.8	2.0	0.1	-	-	-
36	Cucumis callosus	40	1.0	2.5	0.1	-	-	-	-	-	-	-
37	Cyamopsis tetragonoloba	30	2.4	8.0	0.4	-	-	-	-	-	-	-
38	Cymbopogon jwarncusa	30	0.7	2.3	0.2	20	0.6	3.0	0.2	30	0.5	1.7
39	Cynodon dactylon	40	3.1	7.8	0.8	40	1.3	3.3	0.2	60	1.3	2.2
40	Cyperus arenarius	40	0.9	2.3	0.1	30	1.1	3.6	0.1	20	0.3	1.5
41	C. rotundus	80	2.2	2.8	0.3	50	1.4	2.8	0.2	40	0.8	2.0
42	Dactyloctenium aegyptium	50	3.7	7.4	0.8	50	1.6	3.2	0.3	-	-	-
43	D. sindicum	70	2.1	3.0	0.6	60	1.7	2.8	0.4	-	-	-
44	Datura inoxia	10	0.1	1.0	0.1	40	0.9	2.3	0.6	30	0.5	1.7
45	Desmostachya biinnata	20	0.6	3.0	0.2	-	-	-	-	-	-	-

46	Dicoma tomentosa	40	0.8	2.0	1.3	-	-	-	-	-	-	-
47	Digeria alternifolia	20	0.3	1.5	0.1	-	-	-	-	-	-	-
48	Digitaria cilliaris	30	1.4	4.7	0.2	-	-	-	-	-	-	-
49	Eragrostis ciliaris	40	2.8	7.0	0.4	-	-	-	-	-	-	-
50	Erianthus munja	10	0.3	3.0	0.7	40	0.4	1.0	0.8	60	0.9	1.5
51	Euphorbia granulata	40	0.9	2.3	0.5	-	-	-	-	-	-	-
52	Fagonia cretica	60	2.3	3.8	1.9	20	0.7	3.5	0.5	-	-	-
53	Farsetia hamiltonii	70	4.3	6.1	0.5	-	-	-	-	-	-	-
54	Gisekia pharnacioides	80	6.1	7.6	0.9	-	-	-	-	-	-	-
55	Heliotropium marifolium	60	2.4	4.0	0.8	20	0.4	2.0	0.1	-	-	-
56	H. subulatum	20	1.8	9.0	0.3	40	1.0	2.5	0.3	-	-	-
57	Indigofera cordifolia	60	4.2	7.0	0.5	-	-	-	-	-	-	-
58	Leptadenia pyrotechnica	20	0.3	1.5	1.1	40	0.9	2.3	2.6	80	1.4	1.8
59	Lycium barbarum	10	0.2	2.0	0.5	30	0.7	2.3	0.8	30	0.6	2.0
60	Malva parviflora	10	0.1	1.0	0.1	-	-	-	-	-	-	-
61	Maytenus emarginata	10	0.1	1.0	0.6	10	0.1	1.0	0.8	10	0.1	1.0
62	Mollugo cerviana	80	7.1	8.9	0.9	-	-	-	-	-	-	-
63	M. nudicaulis	60	8.7	14.5	0.6	-	-	-	-	-	-	-
64	Momordica dioica	30	0.5	1.7	0.2	-	-	-	-	-	-	-
65	Panicum antidotale	50	1.5	3.0	0.9	40	1.1	2.8	1.3	10	0.1	1.0
66	P. turgidum	60	1.3	2.1	1.1	30	0.7	2.3	0.7	20	0.5	2.5
67	Parkinsonia aculeata	10	0.1	1.0	1.3	10	0.1	1.0	0.8	10	0.1	1.0
68	Pavonia arabica	10	0.2	2.0	0.3	-	-	-	-	-	-	-
69	Pedalium murex	10	0.1	1.0	0.1	-	-	-	-	-	-	-
70	Peristrophe bicalyculata	30	1.4	4.7	0.2	-	-	-	-	-	-	-
71	Phyllanthus amarus	30	1.6	5.3	0.3	30	0.7	2.3	0.1	-	-	-
72	Prosopis cineraria	10	0.1	1.0	2.4	10	0.1	1.0	7.7	10	0.1	1.0
73	Ricinus communis	10	0.1	1.0	1.1	10	0.1	1.0	0.7	10	0.1	1.0
74	Salvadora persica	10	0.1	1.0	3.4	10	0.1	1.0	2.2	10	0.1	1.0
75	Solanum nigrum	20	0.2	1.0	0.4	20	0.3	1.5	0.6	10	0.2	2.0
76	S. surattense	10	0.1	1.0	0.4	20	0.3	1.5	0.4	10	0.1	1.0
77	Sonchus asper	20	0.3	1.5	0.4	30	0.7	2.2	0.7	20	0.3	1.5
78	Tamarix aphylla	10	0.1	1.0	2.1	10	0.1	1.0	0.4	10	0.1	1.0
79	Tecomella undulata	20	0.2	1.0	6.9	10	0.1	1.0	8.6	20	0.2	1.0
80	Tephrosia purpurea	50	1.2	2.4	0.3	70	1.7	2.4	0.4	80	2.4	3.0
81	Tetrapogon tenellus	30	0.8	2.7	0.2	-	-	-	-	-	-	-
82	Tragus biflorus	10	0.2	2.0	0.1	-	-	-	-	-	-	-
83	Trianthema triquetra	30	0.3	1.0	0.1	-	-	-	-	-	-	-
84	Tribulus terrestris	70	6.8	9.7	1.8					-	-	-
85	Trigonella corniculata	20	0.9	4.5	0.3	-	-	-	-	-	-	-
86	Verbesina encelioides	10	0.2	2.0	0.3	20	0.2	1.0	0.5	-	-	-
87	Withania somnifera	20	0.2	1.0	0.6	20	0.5	2.5	0.6	30	0.3	1.0
88	Xanthium strumarium	20	0.2	1.0	0.2	30	0.3	1.0	0.5	10	0.1	1.0
89	Zaleya redimita	20	0.1	0.5	0.1	-	-	-	-	-	-	-
90	Zizipus nummularia	10	0.1	1.0	1.4	10	0.1	1.0	1.9	20	0.2	1.0

F = Frequency, D = Density, Ab = Abundance, Dom = Dominanace, and - = Plants not seen.

Table 3 Basic quantitative parameters of plant species in various seasons at site-III during 2014-2016

S. No.	Plant species	Rainy				Winter				Summer		
		F	D	A	Dom	F	D	A	Dom	F	D	A
1	Acacia jacqemontii	10	0.1	1.0	1.2	20	0.2	1.0	1.6	10	0.1	1.0
2	A. nilotica	20	0.3	1.5	6.7	10	0.1	1.0	1.4	20	0.2	1.0
3	Aerva persica	40	0.9	2.3	1.3	60	1.1	1.8	0.4	60	1.1	1.8
4	A. pseudotomentosa	40	1.1	2.8	1.8	40	0.9	2.3	0.6	40	0.7	1.8
5	Albizia lebbek	20	0.2	1.0	1.3	10	0.1	1.0	0.4	10	0.1	1.0
6	Amaranthus blitum	70	2.2	3.1	0.3	20	0.5	2.5	0.1	-	-	-
7	A. viridis	70	1.7	2.4	0.5	-	-	-	-	-	-	-
8	Anagallis arvensis	-	-	-	-	60	3.1	5.2	1.1	-	-	-
9	Anticharis linearis	70	2.6	3.7	0.6	-	-	-	-	-	-	-
10	Argemone mexicana	30	0.5	1.7	0.8	30	0.7	2.3	1.5	30	0.6	2.0
11	Aristida funiculata	50	1.7	3.4	0.5	-	-	-	-	-	-	-
12	Arnebia hispidissima	40	2.0	5.0	0.3	-	-	-	-	-	-	-
13	Balanites aegyptiaca	20	0.2	1.0	2.9	20	0.2	2.0	1.1	20	0.3	1.5
14	Barleria cristata	30	0.5	1.7	1.2	10	0.3	3.0	0.2	-	-	-
15	Bauhinia recemosa	10	0.1	1.0	0.1	20	0.2	1.0	0.7	-	-	-
16	Blepharis sindica	40	0.6	1.5	0.3	30	0.6	2.0	0.5	-	-	-
17	Blumea lacera	20	0.4	2.0	0.2	-	-	-	-	-	-	-
18	Boerhavia diffusa	40	0.6	1.5	0.6	60	1.1	1.8	2.1	-	-	-
19	Borreria articularis	50	1.1	2.2	0.1	-	-	-	-	-	-	-
20	Brachiaria ramosa	20	0.5	2.5	0.3	-	-	-	-	-	-	-
21	Calotropis procera	30	0.4	1.3	0.8	70	1.3	1.9	3.5	50	0.9	1.8
22	Capparis decidua	40	0.7	1.8	1.7	60	1.0	1.7	2.9	60	0.7	1.2
23	Cenchrus biflorus	80	4.4	5.5	0.8	70	2.6	3.7	0.2	-	-	-
24	C. ciliaris	40	2.9	7.3	0.9	30	1.4	4.7	0.3	-	-	-
25	C. setigerus	50	3.0	6.0	1.0	-	-	-	-	-	-	-
26	Chenopodium album	-	-	-	-	40	0.9	2.3	0.1	-	-	-
27	C. murale	-	-	-	-	60	1.6	2.7	0.3	-	-	-
28	Chloris virgata	30	0.5	1.7	0.3	-	-	-	-	-	-	-
29	Citrullus colocynthis	50	0.8	1.6	0.2	40	0.7	1.8	0.3	-	-	-
30	C. lanatus	40	0.6	1.5	0.2	-	-	-	-	-	-	-
31	Cleome viscosa	20	0.9	4.5	0.9	-	-	-	-	-	-	-
32	Clerodendrum phlomidis	30	0.3	1.0	0.5	10	0.1	1.0	0.2	20	0.2	1.0
33	Corchorus tridens	40	1.4	3.5	0.1	30	0.8	2.7	0.1	20	-	-
34	C. depressus	20	0.6	3.0	0.1	60	1.4	2.3	1.0	30	-	-
35	Cotula hemispherica	30	0.5	1.7	0.3	20	0.2	1.0	0.2	-	-	-
36	Crotalaria burhia	20	0.2	1.0	0.4	70	1.7	2.4	0.7	80	2.0	2.5
37	Ctenolepis cerasiformis	60	1.3	2.2	0.2	-	-	-	-	-	-	-
38	Cucumis callosus	60	0.7	1.2	0.2	-	-	-	-	-	-	-
39	Cymbopogon jwarncusa	30	0.7	2.3	0.1	20	0.5	2.5	0.1	40	0.8	2.0
40	Cynodon dactylon	40	2.7	6.8	0.3	60	2.2	3.7	0.2	60	1.1	1.8
41	Cyperus arenarius	60	1.7	2.8	0.2	40	1.4	3.5	0.2	50	1.0	2.0
42	C. rotundus	40	1.1	2.8	0.1	60	1.6	2.7	0.2	70	1.8	2.6
43	Dactyloctenium aegyptium	70	4.6	6.6	1.1	-	-	-	-	-	-	-

44	Datura inoxia	20	0.2	1.0	0.3	30	0.7	2.3	0.4	20	0.2	1.2
45	Desmostachya biinnata	50	2.2	4.4	0.6	-	-	-	-	-	-	-
46	Dichanthium annulatum	40	1.3	3.3	0.7	-	-	-	-	-	-	-
47	Dicoma tomentosa	30	0.7	2.3	0.4	-	-	-	-	-	-	-
48	Digitaria cilliaris	40	1.1	2.8	0.3	-	-	-	-	-	-	-
49	Eragrostis ciliaris	50	2.6	5.2	0.9	-	-	-	-	-	-	-
50	Erianthus munja	10	0.2	2.0	0.2	30	0.5	1.7	0.2	30	0.7	2.3
51	Euphorbia granulata	10	0.3	3.0	0.7	-	-	-	-	-	-	-
52	Fagonia cretica	60	1.6	2.7	0.9	-	-	-	-	-	-	-
53	Farsetia hamiltonii	60	2.5	4.2	1.1	-	-	-	-	-	-	-
54	Gisekia pharnacioides	70	6.5	9.2	1.1	-	-	-	-	-	-	-
55	Heliotropium marifolium	40	1.9	4.8	1.2	-	-	-	-	-	-	-
56	H. subulatum	60	1.0	1.7	0.1	-	-	-	-	-	-	-
57	Indigofera linifolia	60	2.7	4.5	1.4	-	-	-	-	-	-	-
58	Leptadenia pyrotechnica	20	0.2	1.0	0.7	60	0.9	1.5	3.1	70	1.4	2.0
59	Lycium barbarum	30	0.4	1.3	0.3	30	1.1	3.7	0.2	40	0.9	2.3
60	Maytenus emarginata	10	0.1	1.0	0.4	10	0.1	1.0	0.5	20	0.2	1.0
61	Mollugo cerviana	80	6.4	8.0	2.2	-	-	-	-	-	-	-
62	M. nudicaulis	60	3.8	6.3	0.9	-	-	-	-	-	-	-
63	Momordica dioica	20	0.6	3.0	0.2	-	-	-	-	-	-	-
64	Mukia maderaspatana	30	0.7	2.3	0.4	-	-	-	-	-	-	-
65	Panicum antidotale	40	1.1	2.8	0.5	30	0.6	2.0	0.2	30	0.3	1.0
66	P. turgidum	40	1.0	2.5	0.3	40	0.8	2.0	0.3	10	0.1	1.0
67	Pavonia arabica	30	0.6	2.0	0.2	-	-	-	-	-	-	-
68	Pedalium murex	20	0.2	1.0	0.3	-	-	-	-	-	-	-
69	Peristrophe bicalyculata	30	1.1	3.7	0.6	-	-	-	-	-	-	-
70	Phyllanthus amarus	40	0.9	2.3	0.2	-	-	-	-	-	-	-
71	Prosopis cineraria	10	0.1	1.0	1.8	10	0.1	1.0	6.5	20	0.2	1.0
72	P. juliflora	10	0.1	1.0	3.7	10	0.1	1.0	9.1	20	0.2	2.0
73	Pulicaria crispa	20	0.6	3.0	0.6	-	-	-	-	-	-	-
74	Salvadora persica	10	0.1	1.0	5.6	10	0.1	1.0	7.3	10	0.1	1.0
75	Solanum nigrum	10	0.1	1.0	0.2	30	0.5	1.7	0.7	10	0.1	1.0
76	Tecomella undulata	10	0.1	1.0	3.7	10	0.1	1.0	5.2	20	0.2	1.0
77	Tephrosia purpurea	60	0.9	1.5	2.9	80	1.6	2.0	3.1	70	1.7	2.4
78	Tetrapogon tenellus	50	1.1	2.2	0.5	-	-	-	-	-	-	-
79	Tragus biflorus	60	0.9	1.5	0.8	-	-	-	-	-	-	-
80	Trianthema triquetra	40	0.8	2.0	0.7	-	-	-	-	-	-	-
81	Tribulus terrestris	60	2.2	3.7	0.2	-	-	-	-	-	-	-
82	Verbesina encelioides	30	0.3	1.0	0.7	30	0.5	1.7	0.9	-	-	-
83	Withania somnifera	20	0.2	1.0	0.2	20	0.5	2.5	0.2	20	0.3	1.5
84	Xanthium strumarium	20	0.2	1.0	0.7	30	0.3	1.0	0.8	40	0.4	1.0
85	Zizipus mauritiana	20	0.2	1.0	1.7	10	0.1	1.0	3.1	10	0.1	1.0
86	Z. nummularia	10	0.1	1.0	0.7	20	0.2	1.0	2.1	20	0.2	1.0

F = Frequency, D = Density, Ab = Abundance, Dom = Dominanace, and - = Plants not seen.

Table 4 Importance Value Index (IVI) of plant species in various seasons at sites I - III during 2014-2016

S. No.	Plant species	Site-I			Site-II			Site-III	
		R	W	S	R	W	S	R	W
1	Abutilon indicum	0.58	4.61	-	-	-	-	-	
2	Acacia nilotica	2.57	3.29	3.41	2.88	8.99	2.26	11.10	5.12
3	A. jacqemontii	-	-	-	1.50	5.64	5.11	2.24	6.68
4	A. senegal	1.20	1.67	2.63	-	-	-	-	-
5	Aerva persica	0.91	7.04	10.50	2.20	6.83	10.80	4.16	8.49
6	A. pseudotomentosa	2.24	8.87	8.83	2.87	5.80	9.06	5.12	7.15
7	Ageratum conyzoides	2.24	1.87	-	2.01	2.05	-	-	-
8	Albizia lebbek	1.19	2.36	1.69	1.10	1.69	2.94	2.81	2.15
9	Amaranthus blitum	4.55	3.78	-	2.50	-	-	4.92	3.13
10	A. viridis	-	-	-	-	-	-	4.72	-
11	Anagallis arvensis	-	9.60	-	-	8.15	-	-	6.72
12	Andropogon pumilus	-	-	-	2.74	-	-	-	-
13	Anticharis linearis	5.59	-	-	6.75	-	-	5.78	-
14	Argemone mexicana	1.41	3.89	9.87	0.72	3.37	10.30	2.68	8.55
15	Aristida funiculata	11.64	-	-	2.04	-	-	4.08	-
16	Arnebia hispidissima	6.15	-	-	1.51	-	-	3.76	-
17	Balanites aegyptiaca	1.50	1.46	3.89	1.88	3.98	3.99	5.23	5.20
18	Barleria cristata	1.18	3.76		-	-	-	3.28	2.16
19	Bauhinia racemosa	-	-	-	-	-	-	0.57	4.01
20	Blepharis sindica	9.80	5.36	-	4.86	4.15	-	2.34	4.44
21	Blumea lacera	-	-	-	-	-	-	1.35	-
22	Boerhavia diffusa	3.85	9.49	-	2.93	7.08	-	2.80	13.50
23	Borreria articularis	4.92	-	-	3.14	-	-	2.87	-
24	Brachiaria ramosa	8.28	-	-	1.76	-	-	1.60	-
25	Calotropis procera	3.91	8.78	12.30	3.58	7.43	19.10	2.58	19.00
26	Capparis decidua	1.44	6.00	8.80	4.01	9.42	13.60	4.56	15.60
27	Cenchrus biflorus	8.26	7.58		6.18	7.12	-	8.22	13.10
28	C. ciliaris	8.02	5.62	12.10	4.90	5.94	-	5.58	7.09
29	C. setigerus	-	-	-	4.39	4.96	-	6.15	-
30	Chenopodium album	-	7.32	-	-	7.25	-	-	5.67
31	C. murale	-	9.71	-	-	-	-	-	9.70
32	Chloris virgata	-	-	-	-	-	-	1.92	
33	Citrullus colocynthis	2.90	3.27		2.61	4.11		2.71	5.66
34	C. lanatus	1.06	-	-	1.58	-	-	2.19	-
35	Cleome viscosa	2.03	2.49		2.35	1.87		2.91	-
36	Clerodendrum phlomidis	2.60	5.50	3.49	1.42	2.26	1.77	2.02	1.56
37	Convolvulus microphyllus	-	-	-	0.52	-	-	-	-
38	Corchorus depressus	13.89	7.22	-	5.11	5.95	-	1.40	11.20
39	C. tridens	5.43	4.21		7.96	5.96		2.85	4.70
40	Cordia gharaf	-	-	-	0.69	1.31	1.71	-	-
41	Cotula hemispherica	-	-	-	-	-	-	1.92	1.11
42	Crotalaria burhia	2.26	10.70	12.50	2.89	8.88	20.40	1.45	11.90
43	Ctenolepis cerasiformis	3.08	-	-	5.59	4.33	-	3.54	-
44	Cucumis callosus	0.92	-	-	2.44	-	-	2.93	-
45	Cyamopsis tetragonoloba	1.15	-	-	3.66	-	-	-	-
46	Cymbopogon jwarncusa	1.39	1.10	2.39	1.89	2.91	5.49	1.82	3.13
47	Cynodon dactylon	9.26	17.60	5.62	5.22	5.93	12.50	4.47	11.20

48	Cyperus arenarius	3.34	4.39	7.38	2.24	4.49	5.11	3.94	7.46
49	C. rotundus	-	-	-	5.02	6.52	5.67	2.55	9.40
50	Dactyloctenium aegyptium	3.75	-	-	6.13	7.28	-	8.56	-
51	D. sindicum	-	-	-	5.17	8.42	-	-	-
52	Datura inoxia	0.52	5.90	9.18	0.55	5.68	5.86	1.30	5.29
53	Desmostachya biinnata	4.79	-	-	1.57	-	-	4.73	-
54	Dichanthium annulatum	-	-	-	-	-	-	3.66	-
55	Dicoma tomentosa	2.04	3.98	-	3.32	-	-	2.27	-
56	Digeria alternifolia	2.27	-	-	1.11	-	-	-	-
57	Digitaria cilliaris	2.17	-	-	2.59	-	-	2.85	-
58	Echinops echinatus	1.75	-	-	-	-	-	-	-
59	Eclipta alba	1.51	-	-	-	-	-	-	-
60	Eragrostis ciliaris	3.43	-	-	4.39	-	-	5.59	-
61	Erianthus munja	1.74	5.66	2.97	1.72	5.09	13.80	0.83	4.09
62	Euphorbia granulata	1.84	-		2.94	-	-	1.68	-
63	E. hirta	2.12	-	-	-	-	-	-	-
64	Fagonia cretica	6.67	-	-	6.92	3.93	-	4.90	-
65	Farsetia hamiltonii	3.76	-	-	6.87	-	-	6.12	-
66	Gisekia pharnacioides	4.95	-		8.97	-	-	10.30	-
67	Glossocardia setosa	1.29	-	-		-	-	-	-
68	Heliotropium marifolium	0.43	-	-	5.38	2.37		5.02	-
69	H. ovalifolium	2.31	-	-	-	-	-	-	-
70	H. subulatum	2.39	-	-	2.75	5.38	-	3.09	-
71	Indigofera cordifolia	7.25	-	-	6.43	-	-	6.77	-
72	I. linifolia	6.77	-	-	-	-	-	-	-
73	Launea procumbens	3.75	-	-	-	-	-	-	-
74	Leptadenia pyrotechnica	2.04	9.62	10.10	2.66	10.60	22.70	1.90	15.90
75	Lycium barbarum	2.91	2.83	6.03	1.20	5.30	7.18	1.82	5.90
76	Malva parviflora	0.91	-	-	0.49	-	-	-	-
77	Maytenus emarginata	1.20	1.31	4.84	1.38	2.63	3.69	1.03	2.45
78	Mollugo cerviana	7.88	-	-	10.30	-	-	12.40	-
79	M. nudicaulis	5.74	-	-	10.50	-	-	7.13	-
80	Momordica dioica	0.53		-	1.72	-	-	1.55	-
81	Mukia maderaspatana	-	-	-	-		-	2.27	-
82	Panicum antidotale	-	-	-	4.40	7.97	1.95	3.15	6.13
83	P. turgidum	-	-	-	4.86	4.92	5.49	2.75	5.47
84	Parkinsonia aculeata	1.12	1.32	2.81	2.42	2.60	3.23	-	-
85	Pavonia arabica	0.69	-	-	0.94			1.87	
86	Pedalium murex	0.45	-	-	0.58	-	-	1.30	-
87	Peristrophe bicalyculata	2.16	-	-	2.59	-	-	2.98	-
88	Phyllanthus amarus	1.47	-	-	2.83	-	-	2.49	
89	Polygala irregularis	0.93	-	-	-	-	-	-	-
90	Prosopis cineraria	4.13	7.82	1.83	4.15	4.86	4.92	3.14	2.45
91	P. juliflora	3.31	11.80	7.85	-	-	-	1.48	2.44
92	Pulicaria crispa	1.59	-	-	-	-	-	2.16	-
93	Ricinus communis	0.54	2.37	1.71	2.17	2.41	3.40	-	-
94	Salvadora persica	4.67	8.04	11.40	5.70	6.03	17.10	2.84	4.82
95	Solanum nigrum	0.79	5.52	4.02	1.42	3.15	4.59	0.72	5.58
96	S. surattense	1.53	2.32	3.96	0.96	2.86	2.70	-	-
97	Sonchus asper	1.94	3.85	6.14	1.58	4.92	3.91	-	-

98	Tamarindus indica	0.67	1.81	2.59	-	-	-	-	-
99	Tamarix aphylla	-	-	-	3.70	1.67	2.18	-	-
100	Tecomella undulata	5.20	16.10	31.20	11.40	11.90	19.10	2.99	4.53
101	Tephrosia purpurea	10.24	11.90	15.10	3.23	8.81	21.20	7.22	13.40
102	Tetrapogon tenellus	2.23	-	-	1.96	-	-	3.47	-
103	Tragus biflorus	3.36	-	-	0.53	-	-	4.04	-
104	Trianthema portulacastrum	4.85	-	-	-	-	-	-	-
105	T. triquetra	-	-	-	1.33	-	-	3.15	-
106	Tribulus terrestris	8.16	-	-	11.90	-	-	4.45	-
107	Trigonella corniculata	2.37	-	-	1.94	-	-	-	-
108	Verbesina encelioides	0.92	1.22	-	0.91	1.67	-	2.32	5.57
109	Withania somnifera	1.83	7.34	9.28	1.77	3.62	4.94	1.15	3.43
110	Xanthium strumarium	1.73	5.62	5.60	1.21	3.59	1.77	1.90	5.27
111	Zaleya redimita	2.11	-		0.92	-	-	-	-
112	Ziziphus mauritiana	-	-	-	-	-	-	3.42	4.23
113	Z. nummularia	-	-	-	2.63	3.97	8.32	1.48	5.20

R = Rainy, W = Winter, S = Summer, and - = plants not seen.

Table 5 Indices for diversity, species richness and A/F ratio of plant species in various seasons at different sites during 2014-2016

Parameters	Site-I			Site-II			Site-III	
	R	W	S	R	W	S	R	W
Diversity Index	0.954	0.964	0.947	0.970	0.973	0.941	0.975	0.950
Pielou Index	1.935	2.055	1.951	1.944	2.100	1.957	2.022	1.985
Shannan & Wiener Index	3.782	3.455	3.059	3.800	3.704	3.073	3.891	3.314
Simpson Index	0.045	0.035	0.052	0.029	0.026	0.058	0.025	0.049
Species richness	2.529	2.622	2.621	2.658	2.991	2.687	2.671	2.356
A/F ratio	0.088	0.063	0.059	0.092	0.058	0.056	0.071	0.059
Alpha diversity	4.464	4.677	4.572	4.602	5.091	4.644	4.693	4.340

R = Rainy, W = Winter, and S = Summer.

Table 6 Cody's beta diversity index between studied sites in various seasons

Sites	Rainy	Winter	Summer
I & II	-0.6798	-0.5560	-0.6711
I & III	-0.5881	-0.6595	-0.5479
II & III	-0.7031	-0.5407	-0.7551

Table 7 Total diversity of a landscape unit at studied area

Season	Beta diversity*	Alpha diversity*	Sites studied	Gamma diversity
Rainy	-0.657	4.571	3	6.914
Winter	-0.585	4.779	3	7.194
Summer	-0.658	4.475	3	6.817

* Mean values

Discussion

There are several ways in which species diversity can be assessed. Generally, a large area provides more resources and is expected to support a large number of species than a smaller area. MacArthur and Wilson (1967) proposed that the number of species encountered is proportional to a power of the area sampled. For the quantification of diversity and comparison of species diversities between different communities in various climatic conditions, is useful to calculate an index for diversity and dominance. Diversity indices are used to quantify biological diversity of vegetation that allows comparison of different samplings, habitats and landscapes. The commonly used form of the diversity index is the Shannon-Wiener Index (Shannon and Weaver, 1949) and for dominance index, Simpson (1949) has derived a formula for calculating index of dominance which shows importance of each species in relation to the community as a whole known as Simpson Index. In any plant community, we find a number of species. The older and more stable the community is, the more will be species diversity. Developing communities at seral stages of succession have less number of species and have high species diversity.

Diversity is not uniformly distributed on the earth. It low in habitats with extreme environmental conditions such as deserts, hot springs, etc. (Wilson, 1992). The older stable climate is expected to support high speciation rates due to more sedentary population and hence geographical isolation, larger number of generations per year and more opportunities for selection. On the other hand, greater spatial heterogeneity would result in low extinction rates due to greater specialization of taxa, more resources, less competition and smaller size of populations. The uneven distribution of biodiversity is also illustrated at regional and ecosystem levels (Aparajita, 2007).

In communities, several topographic gradients, climatic variations and disturbances produce variations in composition and structure of vegetation (Gibson and Hulbert, 1987; Belsky, 1988; Aparajita, 2007). These same factors increase diversity and heterogeneity within communities as well (Belsky, 1986). It is generally observed that areas with high species diversity are found in the middle latitude because of the congenial climatic, edaphic and other factors prevailing therein. Diversity indices have been computed for various ecosystems by different researchers such as Richards (1952), Whittaker (1972), Wilson and Shmida (1984), Aparajita *et al.* (2002), Aparajita (2007), etc. Alpha diversity reflects action of biotic and local abiotic elements of environment (Whittaker, 1960) and its components are sensitive to the size of the sample. Plant species became less diverse, the structure of plant communities became simpler, and the diversity and abundance indices of the plant species decreased moving from the area of less water stress to higher one. Impacts of water stress on arid ecosystems due to low ground-water level and scarce rainfall was apparently one of the major attributes to the low plant species diversity (Chen *et al.*, 2006). In the present studies, the highest frequences in rainy season were exihibited by *Aristidia funiculata*, *Cenchrus biflorus*, *Cynodon dactylon*, *Cyperus rotundus*, *Gisekia pharnacioides Mollugo cerviana* and *Tephrosia purpurea.* While in winter, plant such as *Chenopodium album*, *C. murale*, *Calotropis procera* and *Tephrosia purpurea* and in summer, *C. burhia* and *T. purpurea* show maximum frequency at all sites.

Density is the measure of number per unit area. It is inversely related to the mean distance between individuals. The density of the study area did not show any regular pattern at all sites. Generally, density decreased gradually with time due to a number of factors such as mortality, etc. In general, at all sites, during different seasons different species attained maximum density, which indicate non-overlapping in sharing of common resources. Plant species such as *Mollugo cerviana*, *M. nudicaulis* and *Gisekia pharnacioides* shows highest densities in rainy season, while *Cenchrus biflorus*, *Chenopodium album* and *Crotalaria burhia* in winter, and *Tephrosia purpurea*, *Aerva persica* and *Leptadenia pyrotechnica* in summer. The highest values of dominance were represented by *Corchorus depressus*, *Prosopis cineraria* and *Tecomella undulata* at all the sites. The present studies show that in rainy season plant species such as *Corchorus depressus*, *Aristida funiculata*, *Tecomella undulata*, *Cynodon dactylon*, *Calotropis procera* and *Tribulus terrestris* showed maximum IVI values. *T. undulata* showed maximum importance values i.e. 31.2 among all species at all sites. In winter, *Anagallis arvensis*, *Boerhavia diffusa*, *Capparis decidua*, *Chenopodium murale*, *Crotalaria burhia*, *Cynodon dactylon*, *Leptadenia pyrotechnica* and *Tecomella undulata*, and in summer *Aerva persica*, *Argemone mexicana*, *C. decidua*, *C. burhia*, *L. pyrotechnica* and *T. purpurea* showed maximum IVI values.

The species richness ranged from 2.3 to 2.9 and these data are not good indicators of the relative wealth of species in a community (Sagar and Singh, 1999). The value of Pielou Index shows that distribution of individuals among the species is in evenness. According to Margalef (1972) the values of index fall between 1.5 and 3.5. In the present studies, the values of Pielou Index were lesser in rainy seasons at all the sites and show that in comparison to winter and summer season, individuals were distributed less consistently in rainy. Shannon-Wiener Index was also higher and it ranges from 3.03 to 3.89. Higher values indicate that all species almost represented by the same number of individuals.

In the present studies, A/F ratio shows that vegetation distribution pattern was contagious at all the sites except in summer at site-III, which showed random. The contagious distribution may be an evolutionary character to minimize the interspecific competition among the species. In the present studies, all sites showed sigmoidal curve because of improvements in grass cover and perennials which result in stable habitats.

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